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This report compares new with traditional teaching techniques. A chemistry course, taught by one instructor using two methods, was examined for two quarters. The effects of the two treatment variables, student variables, and interactions among them were tested. The students were randomly assigned to a closed-circuit TV (CCTV) group and a discussion group. Both groups covered the same material, but, in the latter, the teacher encouraged student participation. The rate of verbal teacher behavior that elicited or hindered student participation was calculated and student talk measured at about 13%. Student variables had been determined by natural science, math, and total ACT scores, and by pretests on scientific attitude and method. Student participation was measured by the Kuder Richardson Formula 20. Significant differences between the groups were found only for final examinations, with the discussion group scoring higher than the other. The attitude of the discussion group was higher for the winter quarter, but not for the spring. No significant interactions among variables and no systematic gain from pre- to post-test were found. From these and other findings, six conclusions were reached. There was some evidence in favor of the discussion groups, but little corroboration of the theory of the need for continual learner response and reinforcement. Such techniques as computer-assisted instruction should be studied more fully as alternatives to traditional teaching. (HH)

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# STUDENT ACHIEVEMENT AS A FUNCTION OF VERBAL INTERACTION IN THE CLASSROOM

John Burrell Cook

Since the advent of such new educational "hardware" as closed circuit television (CCTV), intended as a means of instruction in large classes, researchers have become especially interested in comparing innovative teaching techniques to more traditional ways of instruction. The report that comprises this issue of The General College Studies is about such a comparison.

Though curriculum research -- in which a single instructor attempts to improve the little corner of the pedagogical world for which he is responsible -- is common enough in undergraduate institutions, junior college instructors often find that they lack the assistance and the resources necessary for carrying on well-designed and comprehensive statistical studies. Such is not the case for experimenters and researchers in the General College. In the study reported here, for instance, an instructor in the General College had at his disposal all the resources of a large university. As a doctoral candidate in the University of Minnesota's College of Education, he had the encouragement and counsel of his graduate adviser; as a classroom teacher he had his own classes to use as experimental and control groups; as a faculty member of an experimental college, he had available to him the expertise of a Coordinator of Research; as a staff member in the University, he had ready access to computer time for processing his data. In short, the necessary ingredients for successful research were present.

The material presented here constitutes only the summary chapter of the author's study of CCTV instruction as compared to instruction by means of discussion. The complete study is available from the University of Minnesota library and, on microfilm, from University Microfilms, Ann Arbor. Beginning in with the fall term, 1969, Dr. Cook, the author of this excerpt, will be assistant professor of science education at Jacksonville University, Jacksonville, Florida.

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# Student Achievement as a Function of Verbal Interaction in the Classroom

John Burrell Cook

This report is a summary of an experiment in which one course was taught by one instructor using two different instructional methods. The effects of the two treatment variables, of student variables, and the interactions among these variables were tested in terms of criterion variables.

The experiment was carried on during the winter and spring quarters, 1968, at the freshman-sophomore level in the General College of the University of Minnesota. The course studied was GC 7C: Chemistry, an elective general education course with no prerequisites. The course is described in the 1966-1968 General College bulletin as follows:

> GC 7C: Chemistry -- Fundamental principles and laws are selected for study, stressing the development and application of theories and their roots in experience. Topics and demonstrations include classification of matter, reactions, elements, atomic and molecular structure, chemical bonding theory, and other topics which may vary from quarter to quarter. The student should gain a general understanding of both the content and the process of the science of chemistry. (5 cr)

The students who elected the course and attended the first day of class were randomly assigned, either to a closed circuit television (CCTV) group or to a discussion group. Both groups met in the same building at the same hour, but in different rooms. The CCTV group received its instruction through video-taped lectures with demonstrations via the University of Minnesota closed-circuit television facilities. The discussion group, to which thirty students were assigned, met with the instructor in person. They covered essentially the same material, including the same demonstrations, as the CCTV group, but the instructor made a deliberate effort to continually elicit student participation. Using the Flanders-Amidon interaction analysis technique (Flanders, 1961; Amidon and Flanders, 1963), it was possible to measure the ratio of verbal teacher-behavior which tended to elicit student participation to behavior which restricted participation, e.g. lecturing. This ratio, the I/D ratio, was 0.38. The student talk in the discussion classes was measured at about thirteen percent.

The students' ACT scores on natural science, mathematics, and their composite ACT scores were obtained from their college records. The students were also given pretests on two of the main criteria: scientific attitude and understanding of the scientific method. Scientific attitude was measured by

a modified version of the Vitrogan (1966, 1967) Scale for Measuring a Generalized Attitude Toward Science (GATS), and by the investigator-made Test on the Evaluation of Scientific Information (ESI). The Cooley and Klopfer (1961) Test on Understanding Science (TOUS) was used to measure understanding of the scientific method. The extent to which individual students participated was measured in the discussion classes using the Kuder-Richardson (1937) formula 20.

The criteria included measures of cognitive achievement (midquarter and final examinations and TOUS scores), development of a scientific attitude (GATS, ESI-true, and ESI-false scores), and the Michigan State Attitude Toward Any College Course (Cooke, 1952). Using Kuder-Richardson formula 20 with data from the experiment, the estimated internal consistencies were: midquarter, 0.812; final, 0.859; TOUS, 0.768; GATS, 0.648; ESI trues, 0.674; and ESI falses, 0.660.

Significant differences between groups taught by different instructional methods were found only for mean final-examination scores, with the discussion groups averaging higher than the CCTV groups. Significant differences in the performances of students between the two quarters, winter and spring, were also found only for the final-examination scores, with the winter quarter students averaging higher. Controlling for pretest and/or ability (as measured by ACT comprehensive scores) by means of analysis of covariance produced the same results: only on final-examination scores were there significant differences among the four groups (winter discussion, winter CCTV, spring discussion, and spring CCTV). In attitude toward the course the discussion group averaged significantly higher than the CCTV group in the winter quarter but not in the spring quarter.

Of the student variables, significant differences among the four groups were found for ESI-true pretest scores only. Significant differences between high and low ability groups (based on ACT comprehensive scores) were found only on midquarter examination and TOUS means. Tests of significance showed that student participation was positively correlated with midquarter and final examination scores, negatively correlated with ESI-false posttest scores, and not significantly correlated with any of the other measured variables.

No significant interactions among any variables were found.

Generally speaking, there was no systematic gain from pretest to posttest on TOUS, GATS, ESI-true, or ESI-false scores.

There were no significant differences among the four groups in proportion of dropouts.

## Conclusions

The population of inference was all General College students, present or future, who elect GC 7C: Chemistry, taught by the instructor in the experiment and who attend the first day of class. It would be improper to make direct

inferences to students in other courses taught by other instructors; however, to make more general inferences, it would be proper to consider the results of this experiment in conjunction with other similar experiments involving other courses and other instructors.

Conclusions specific to the population of inference are: (1) On the average, students taught by the discussion method scored higher on the final examination and liked the course better than students taught by the CCTV method. (2) High-ability students across treatments performed better than low-ability students on the midquarter examinations and on the TOUS, but not on the other tests. (3) Mid-quarter and final examination scores were positively correlated with the extent to which students participate in discussion, in a class taught by the discussion method, while ESI-false posttest scores were negatively correlated with participation. No other variables were correlated with participation. (4) On the average, the students did not gain from the beginning of the quarter to the end in their ability to score on the TOUS, the GATS, or the ESI, false subscores or true subscore This may have been caused by inadequacies in the instruments, the instruction, or both. Since there was generally no achievement as measured by these instruments, no treatment effects were possible on these variables. (5) On the average, winter quarter students achieved higher scores on the final examination than did spring quarter students, but there were no significant differences between quarters in the mean scores on other instruments used in the experiment. (6) There were no significant differences between instructional methods or quarters in the proportion of students in each group who dropped out during the quarter.

Since the population of inference is a hypothetical, infinite population, the experimental sample was not a random sample, and inferences to other present and future samples are limited to those which resemble the experimental sample in methods, materials, students, and instructor.

This study does not allow one to reach any more general conclusion about instructional methods; however, the fact that the discussion students achieved significantly higher scores, on the average, on the final examination added a little bit of evidence in favor of small discussion classes as opposed to CCTV classes or large lectures and in favor of classes in which there was more student participation. The significant correlations reinforced this point because the more that students participated, in general, the higher were the scores they obtained on the midquarter and final examinations. The study also provided an even smaller amount of corroboration for theories of learning which hypothesize the need for continual response by the learner followed by reinforcement.

It follows from the results of this experiment that, other things being equal, it would be better to teach GC 7C: Chemistry by means of small discussion classes

than by CCTV lectures, or, more generally, by methods which encourage student participation than by methods which discourage participation. However, other things being unequal, as they usually are, the differences between teaching methods were small, and other factors, particularly economics, could easily be more decisive.

A recommendation emerging from this study of GC 7C is that more work needs to be done on defining, teaching, and measuring the achievement of affective objectives and objectives concerning the understanding of the "process" of chemistry as a science. This recommendation could probably be widely applied in science education.

While it is not possible to draw firm conclusions from results of "no significant difference," it is possible to propose some possible explanations for the outcomes. Basically, the results obtained in this study mean that the differences observed in the measured variables were not greater than those one would expect from typical, random variations. While it is not reasonable to suppose that the parameters compared were identical, it is reasonable to suggest that they may have been approximately the same size. Other explanations are that the measuring instruments used were not sufficiently sensitive or that they were improperly used. There may also have been such an unusually large variation among individuals that differences between groups were masked. Finally there is "type-two error:" the possibility that samples were drawn with statistics which were close together from populations whose corresponding parameters were different by an important amount. Since results of "no significant difference" imply the inclusive disjunction of all of these explanations, and perhaps others, choosing among the explanations will have to depend on additional evidence.

The results of this experiment provided some support for those who emphasize defining objectives in behavioral terms. Where examinations were used which were written in accordance with a list of specific, behavioral objectives, i.e. the midquarter and final examinations, the instruments were sensitive enough to measure differences among groups. When "outside" instruments not specifically designed for the study were used to measure objectives stated only in general terms, there was not even much gain from pretest to posttest by the students, let alone significant achievement differences among groups.

This experiment was of some value for those who must make decisions about college classroom instruction, because it was conducted within the framework of fairly typical contemporary college classroom environments. Future educational settings may be quite different; further research might be aimed at testing learning theories, or at the use of radical technological innovations. Also, the extent and kind of student participation may be a fruitful variable to study further. In the discussion classes in this experiment, participation was still

a non-conforming behavior. Techniques, such as computer-assisted instruction, which insure the continual active participation of all students should be investigated more fully as alternative to the traditional classroom.

A major implication of classroom research, including this experiment, is that traditional classroom instruction is highly inefficient and any innovation is unlikely to be less effective. There is everything to gain and very little to lose in trying out new techniques.

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